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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	(EARLIEST) PRIORITY DATE CLAIMED
PCT/JP00/02990	May 10, 2000	May 10, 1999

TITLE OF INVENTION: **ROBOT AND ITS CONTROL METHOD AND RECORDING MEDIUM**

APPLICANT(S) FOR DO/EO/US: **Makoto INOUE and Takeshi YAMAGISHI**

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

    PCT/RO/101, PCT/IB/301, 304, 308

    PCT/ISA/210, 220

    9 Sheets of Drawings, 1 Page Abstract

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17. ☒ The following fees are submitted (CALCULATIONS /PTO USE ONLY

Basic National Fee (37 CFR 1.492(a)(1)-(5):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1,000.00**
International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$ 860.00**
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1 445(a)(2)) paid to USPTO	**$ 710.00**
International preliminary examination fee paid to USPTO (37 CFR 1 482) but all claims did not satisfy provisions of PCT Article 33(1)-(4	**$ 690.00**
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)	**$ 100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT = **($ 860.00**

Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)). ($

18 Claims	/Number Filed	/	Number Extra	/Rate	($
Total Claims	/ **18** - 20 =	/	**0**	/X **$18.00**	($ **0.00**
Independent Claims	/ **3** - 3 =	/	**0**	/X **$80.00**	($ **0.00**

MULTIPLE DEPENDENT CLAIM(S) (if applicable) /+ **$270.00** ($

TOTAL OF ABOVE CALCULATIONS = **($ 860.00**

☐ Applicant claims small entity status. See 37 C.F.R. 1.27. The fees indicated above are reduced by ½. ($

SUBTOTAL = **($ 860.00**

Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). + ($

TOTAL NATIONAL FEE = **($ 860.00**

Fee for recording the enclosed assignments (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property + ($

TOTAL FEES ENCLOSED = **($ 860.00**

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a. ☒ A check in the amount of $**860.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **50-0320**. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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REGISTRATION NUMBER

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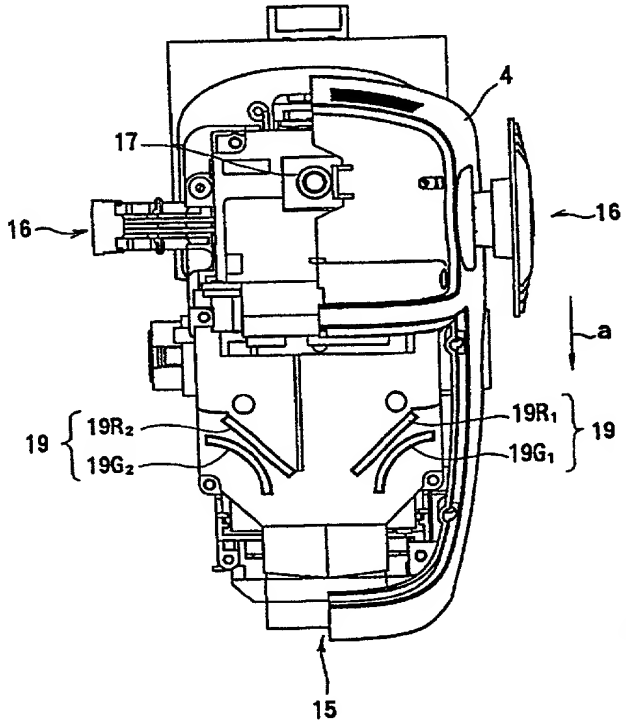
(54)Title: **ROBOT DEVICE, ITS CONTROL METHOD, AND RECORDED MEDIUM**

(54)発明の名称 ロボット装置及びその制御方法並びに記録媒体

(57) **Abstract**

A robot device having light-emitting elements looking like eyes which are turned on/off for expression of its emotion according to the output of an external sensor. The user can recognize the emotion of the robot device based on the light emission state of the light-emitting elements, which enhances the attachment and curiosity of the user to the robot device and the entertainment afforded by the robot device is further improved. Its control method and a recorded medium are also disclosed.



DESCRIPTION

ROBOT AND ITS CONTROL METHOD AND RECORDING MEDIUM

TECHNICAL FIELD

The present invention relates to a robot and its control method and recording medium, and is suitably applied to a pet robot.

BACKGROUND ART

In recent years, a four-legged walking pet robot that performs actions autonomically responding to the direction from the user and the surrounding environment has been developed by the applicant of the present invention. Such pet robot has the similar shape to dogs and cats being raised in general households and acts responding to the direction from the user and the surrounding environment.

In such pet robot, if the emotion such as "anger" and "joy" can be expressed in response to the action of the user such as "hit" and "pat", the user can communicate with the pet robot smoothly. Hence, it is considered that the user's affection and curiosity to the pet robot can be improved and entertainment factor can be further improved.

DISCLOSURE OF THE INVENTION

The present invention has been done considering the above point and is proposing a robot and its control method and recording medium capable of further improving the entertainment factor.

To obviate such problem according to the present invention, we provide a light emitting means to function as eyes for the sake of appearance, an external sensor for detecting the external condition and/or the input from the outside, and a control means for flashing the light emitting means in order to express emotions based on the output of the external sensor in the robot. Accordingly, the user can easily recognize emotion of said robot. Thus, communications between the user and the robot can be conducted smoothly and the robotic device capable of further improving the entertainment factor can be realized.

Furthermore, according to the present invention, since in the control method of the robot comprising the light emitting means functioning as eyes for the sake of appearance and the external sensor for detecting the external condition and input from the outside, the first step for recognizing the external condition and/or the input from the outside based on the output of the external sensor and the second step for flashing the light emitting means in order to express emotions are provided, the user can easily recognize the emotion of the robot based on the light emitting condition of the light emitting means of the robot. Thus, communications between the user and the robotic device can be

conducted smoothly. Thereby, the control method of the robot capable of further improving the entertainment factor can be realized.

Furthermore, according to the present invention, in the recording medium on which the control program of the robot having the light emitting means functioning as eyes for the sake of appearance and the external sensor for detecting the external condition and/or input from the outside is recorded, the control program having the first step for recognizing the external condition and/or the input from outside based on the output of the external sensor and the second step for flashing the light emitting means to express emotions is recorded. As a result, according to the control program recorded onto this recording medium, since the user can easily recognize emotions of said robotic device based on the light emitting condition of the light emitting means of the robotic device, the communications between the user and the robotic device can be smoothly conducted. Thus, the recording medium capable of further improving the entertainment factor of the robotic device can be realized.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a perspective view showing the construction of a pet robot according to the embodiment of the present invention.

Fig. 2 is a block diagram showing the construction of a pet robot.

Fig. 3 is a perspective view showing the construction of LED.

Fig. 4 is a perspective view showing the construction of LED.

Fig. 5 is a block diagram illustrating the processing of controller.

Fig. 6 is a brief linear diagram illustrating each emotion.

Fig. 7 is a conceptual diagram illustrating the probability automaton.

Fig. 8 is a conceptual diagram showing the condition transition table.

Fig. 9 is a brief linear diagram illustrating the other embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference to the accompanying drawings one embodiment of the present invention will be described in detail hereunder.

(1) Construction of Pet Robot 1 according to the Embodiment of the Present Invention

In Fig. 1, 1 generally shows a pet robot according to the embodiment of the present invention. And this pet robot 1 is comprised of leg units 3A ~ 3D connected respectively to the front and back and left and right of the body unit 2, and a head unit 4 and a tail unit 5 connected respectively to the front edge part and the rear edge part of the body unit 2.

In this case as shown in Fig. 2, a controller 10 for controlling the whole operation of this pet robot 1 and a battery

11 as the power source of this pet robot 1, and an internal sensor unit 14 comprised of a battery sensor 12 and a temperature sensor 13 are stored in the body unit 2.

Moreover, in the head unit 4 a CCD (charge coupled device) camera 15 which functions as actual "eyes", an external sensor unit 18 comprised of a microphone 16 to function as ears and a touch sensor 17, and LED (light emitting diode) to function as "eyes" for the sake of appearance, and a speaker 20 to function as "mouth) are placed respectively on the predetermined positions.

Furthermore, actuators 21_1 ~ 21_n for several degrees of freedom are placed respectively to the joints of leg units 3A ~ 3D, the connecting parts of leg units 3A ~ 3D and the body unit 2, the connecting part of the head unit 4 and the body unit 2, and the root part of the tail 5A in the tail unit 5 (Fig. 1).

Then, the CCD camera 15 of the head unit 4 shoots picture of surrounding condition, and transmits the resultant image signal S1A to the controller 10. Moreover, the microphone 16 collects the command sounds such as "walk", "lie-down" or "chase after a ball" to be given from the user as musical scales via a sound commander (not shown in Fig.) and transmits the resultant audio signal S1B to the controller 10.

Furthermore, as it is clear in Fig. 1, the touch sensor 17 is provided on the upper part of the head unit 4, and detects the pressure received by the physical action such as "pat" and "hit" from the user and outputs the detection result to the controller

10 as a pressure detection signal S1C.

Furthermore, the battery sensor 12, detecting the remaining quantity of the battery 11, outputs the detection result to the controller 10 as a battery remaining quantity detection signal S2A. While the temperature sensor 13 detects the internal temperature of the pet robot 1 and transmits the detection result to the controller 10 as a temperature detection signal S2B.

The controller 10 judges the surrounding and internal condition of the pet robot 1, directions from the user, and the existence or non-existence of actions from the user based on the image signal S1A, audio signal S1B and the pressure detection signal S1C (hereinafter these are all together referred to as external sensor signal S1) to be supplied respectively from the CCD camera 15, the microphone 16 and the touch sensor 17 of the external sensor unit 18, and the battery remaining quantity detection signal S2A and the temperature detection signal S2B (hereinafter these are all together referred to as internal sensor signal S2) to be supplied respectively from the battery sensor and the heat sensor of the internal sensor unit 14.

Then, the controller 10 determines the following action based on this judgement result and the control program stored in the memory 10A in advance, and by driving necessary actuators 21_1 ~ 21_n based on the determined result, makes the head unit 4 swing up and down, and right and left, or makes the tail of the tail unit 5 swing, or driving each of leg units 3A ~ 3D, makes the robot walk.

Furthermore, in this case, by giving the predetermined audio signal S3 to the speaker 20 as required, the controller 10 outputs sounds based on said audio signal S3 to outside, or by outputting the LED driving signal S4 to the LED 19 as "eyes" in appearance, it makes the LED 19 flash.

Accordingly, this pet robot 1 can act autonomically based on the surrounding and internal condition and the existence or non-existence of the command or approach from the user.

Hence the detailed construction of the LED 19 as "eyes" for the sake of appearance of the pet robot 1 will be shown in Fig. 3. As is clear from Fig. 3, the LED 19 comprises a pair of red colors LED $19R_1$ and $19R_2$ emitting red light respectively and a pair of green colors LED $19G_1$ and $19G_2$ emitting green light respectively.

In this case, each of red colors LED $19R_1$ and $19R_2$ of which the light emitting unit has a rectilinear shape with the predetermined length. And these are placed approximately on the middle stage in the longitudinal direction of the head unit 4 so that these becomes closer as proceeding frontward of the head unit 4 shown by an arrow a. Thus, in this pet robot 1, by lighting up these red LED $19R_1$ and $19R_2$ together, this pet robot 1 can show the expression of "anger" as if it gets angry turning up its eyes.

Furthermore, each of green colors LED $19G_1$ and $19G_2$ of which the light emitting unit has an arc shape with the predetermined length. And these are placed on the immediately proceeding places of the corresponding red colors LED $19R_1$ and $19R_2$ on the head unit

4 placing inside of the arc in the front direction (an arrow a). With this arrangement, by lighting up these red colors LED $19G_1$, $19G_2$ together, this pet robot can show the expression of "joy" as if it is laughing.

In this pet robot 1, the upper part of the box body from the near front edge of the head unit 4 to the immediately before the touch sensor 17 is covered with the black semi-transparent cover 4A formed of such as synthetic resin so that these red colors LED $19R_1$, $19R_2$ and green colors LED $19G_1$, $19G_2$ are covered up.

Thus, in this pet robot, these are difficult to be confirmed from the outside when the LED 19 is not lighted up. On the other hand, when the LED 19 is lighted up, these can be easily confirmed visually from the outside. Thereby, the feeling of physical disorder caused by the exposure of "eyes" of two kinds (red color LED $19R_1$, $19R_2$ and green color LED $19G_1$, $19G_2$) can be effectively avoided.

In this connection, in this pet robot 1, the optical axis of the CCD camera 15 which functions as actual "eyes" are placed in parallel with an arrow a on the edge part of the head unit 4. Thus, the front condition to which the head unit 4 is faced can be certainly photographed by this CCD camera 1.

(2) Processing of Controller 10

Next, the processing of controller 10 in the pet robot 1 will be described in detail as follows:

The controller 10 executes various processings as described

above according to the control program stored in the memory 10A. And the processing contents of this controller 10 can be classified according to the functions as shown in Fig. 5; i.e., a condition recognition unit 30 for recognizing external and inner conditions, an emotion/instinct model unit 31 for determining the condition of feeling and instinct based on the recognition result of the condition recognition unit 30, an action determining unit 32 for determining the succeeding action based on the recognition result of the condition recognition unit 30 and the output of the emotion/instinct model unit 31, and an action forming unit 33 for making the pet robot form the action corresponding to the determination result of the action determining unit 32.

Then, these condition recognition unit 30, the motion/instinct model unit 31, the action determining unit 32 and the action forming unit 33 will be described in detail as follows.

(2-1) Construction of Condition Recognition Unit 30

The condition recognition unit 30 recognizes the specific condition based on the external information signal S1 to be given from the external sensor unit 18 (Fig. 2) and the internal information signal S2 to be given from the internal sensor unit 14 (Fig. 2) and notifies the recognition result to the motion/instinct model unit 31 and the action determining unit 32 as a condition recognition information S10.

In practice, the condition recognition unit 30 constantly monitors the image signal S1A given from the CCD camera 15 (Fig.

2) of the external sensor unit 18. And when it detects such as "red round article" or "vertical plane", it recognizes that "there is a ball" or "there is a wall" and notifies the recognition result to the emotion/instinct model unit 31 and the action determining unit 32.

Furthermore, the condition recognition unit 30 constantly monitors the audio signal S1B to be given from the microphone 16 (Fig. 2). And when it recognizes that the command sound such as "walk", "lie down", or "chase after a ball" is entered based on the audio signal S1B, it notifies the recognition result to the emotion/instinct model unit 31 and the action determining unit 32.

Furthermore, the condition recognition unit 30 constantly monitors the pressure detection signal S1C (Fig. 2) to be given from the touch sensor 17 (Fig. 2). And when it detects the pressure of more than the predetermined threshold value and the short period of time (such as less than 2 seconds), it recognizes that "it is hit (is scolded)". And when it detects the pressure of less than the predetermined threshold value and the long period of time (such as over 2 seconds), it recognizes that "it is patted (it is praised)" and notifies the recognition result to the emotion/instinct model unit 31 and the action determining unit 32.

Furthermore, the condition recognition unit 30 constantly monitors the temperature detection signal S2B (Fig. 2) to be given from the temperature sensor 13 (Fig. 2) of the internal sensor unit 14 (Fig. 2). And when it detects the temperature of more than

predetermined temperature, it recognizes that "internal temperature has gone up" and informs the recognition result to the emotion/instinct model unit 31 and the action determining unit 32.

(2-2) Construction of Emotion/Instinct Model Unit 31

The emotion/instinct model unit 31 holds the parameter to show the strength of emotional action on the total of 6 emotional actions, "joy", "sadness", "surprise", "fear", "disgust" and "anger", in each emotional action. Then the emotion/instinct model unit 31 successively updates the parameter value of each emotional action based on the specific recognition result such as "is hit" and "is patted" to be given from the condition recognition unit 30 respectively as the condition recognition information S10, the action determining information S12 showing the determined output action to be given from the action determining unit 32 and the time elapsed.

More specifically, based on the degree of recognition result to be obtained based on the condition recognition information S10 and the output action based the action determining information S12 act upon that emotional action (that is preset) and the degree of control and stimulation received from the other emotional action, the emotion/instinct model unit 31 calculates the parameter value of the emotional action in the following cycle E [t + 1] in utilizing the following EQUATION:

$$E[t+1] = E[t] + k_0 \times \Delta E[t] \quad \ldots\ldots \quad (1)$$

Where the quantity of change of emotional action to be calculated by the predetermined Equation = E [t];
The current parameter value of emotional action = E [t];
Coefficient showing the degree of change its emotional action corresponding to the recognition result = k_0.

Then, the emotion/instinct model unit 31 updates the parameter value of that emotional action by replacing this calculation result with the current parameter value of emotional activity E [t]. In this connection, which emotional action parameter value to each recognition result and each output activity would be updated is predetermined. For example, when the recognition result such as "hit" is given, the parameter value of emotional action of "anger" rises and the parameter of emotional action of "joy" drops. And when the recognition result such as "patted" is given, the parameter of emotional action of "joy" rises and the parameter value of emotional action "sadness" drops. In this connection, more detailed explanations on each emotional action and an example of concrete causes that these emotional actions vary will be shown in Fig. 6.

Similarly, the emotion/instinct model unit 31 holds the parameter showing the strength of desire per desire on four independent desires, "desire for exercise", "desire for love", "appetite for food" and "curiosity". Then the emotion/instinct model unit 31 successively updates these parameter values of

desires based on the recognition result from the condition recognition unit 30, the time elapsed and the notice from the action determining unit 32.

More specifically, the emotion/instinct model unit 31 calculates the parameter value of the desire I [k + 1] in the following cycle using the following EQUATION at the fixed cycle based on the output action of the pet robot 1, the time elapsed and the recognition result on the "desire for exercise", "desire for love" and "curiosity".

$$I[k+1] = I[k] + k_1 \times \Delta I[k] \quad \cdots\cdots \quad (2)$$

where the quantity of desire change to be calculated by the predetermined Equation to be $\Delta I[k]$;
the parameter value of desire of subtraction to be $I[k]$; and the coefficient showing the sensitivity of that desire to be k_1. And by replacing this calculation result with the current desire parameter value $I[k]$, that desire parameter value will be updated. In this connection which desire parameter value to be changed is determined in advance. And when a notice informing that the action has been taken is received from the action determining unit 32, the parameter value of "desire for exercise" will drop.

Moreover, based on the battery remaining quantity detection signal S2A (Fig. 2) to be given via the condition recognition unit 30, the emotion/instinct model unit 31 calculates the parameter

value of "appetite for food" I [k + 1] using the following EQUATION at the fixed cycle.

$$I[k] = 100 - B_L \quad \cdots\cdots (3)$$

Where the remaining quantity of battery to be B_L

Then, the emotion/instinct model unit 31 updates the parameter value of "appetite for food" by replacing this calculation result with the current appetite parameter value I[k].

In this connection, according to the embodiment of the present invention, the parameter value of each motion and each desire is regulated so that these will change within the range from 0 to 100, and also coefficient values k_0 and k_1 are set individually per each emotion and each desire.

(2 - 3) Construction of Action Determining Unit 32

The action determining unit 32 determines the next action based on the condition recognition information S10 to be supplied from the condition recognition unit 30, the parameter value of each emotion and each desire in the emotion/instinct model unit 31, the action model stored in the memory 10A in advance and the time elapsed, and sends out the determination result to the emotion/instinct model unit 31 and the action forming unit 33 as the action determination information S12.

In this case, as a method to determine the next action, the action determining unit 32 uses the algorithm called as

probability automaton for determining whether to transit from one node $NODE_0$ to the same or which other node $NODE_0$ ~ $NODE_n$ based on the transition probability P_0 ~ P_n set respectively to arcs ARC_0 ~ ARC_n connecting between each $NODE_0$ ~ $NODE_n$.

More specifically, a condition transition table 40 per each node $NODE_0$ ~ $NODE_n$ as shown in Fig. 8 is stored in the memory 10A as an action model, and the actin determining unit 32 determines the next action based on this condition transition table 40.

At this point, in the condition transition table 40, the input events (recognition result of the condition recognition unit 30) making the transition as prerequisite in that $NODE_0$ ~ $NODE_n$ are listed in the column of "Input Event" in priority order, and additional conditions on that condition are described on the corresponding lines in the columns of "Name of Data" and "Range of Data".

Accordingly, in the node $NODE_{100}$ defined in the condition transition table of Fig. 8, the following becomes the prerequisite for transferring to the self or the other node; i.e., when the recognition result "detected a ball (BALL)" is given, "size (SIZE)" of the ball to be given with said recognition result is in "the range from 0 to 1000 (0, 1000)", and when the recognition result "obstacle is detected (OBSTACLE)" is given, "the distance (DISTANCE)" to that obstacle to be given with said recognition result is "the range from 0 to 1000 (0, 1000)".

Furthermore, in this node $NODE_{100}$, even in the case where no

recognition result is put in, when either one of parameter values of emotional actions "joy (JOY)", "surprise (SURPRISE)" or "sadness (SADNESS) among the parameter values of each emotional action and each desire of the emotion/instinct model unit 31 to which the action determining unit 32 refers periodically is in "the range from 50 to 100 (50, 100)", it can be transferred to its own or the other node.

Furthermore, in the condition transition table 40, names of nodes that can be transited from the node $NODE_0$ ~ $NODE_n$ are listed in rows of "Node of transiting end" in the column of "Transit probability to other node". And simultaneously, the transit probability of that node $NODE_0$ ~ $NODE_n$ at the time when all conditions described in each line of "Name of input event", "Data value" and " Range of data" are satisfied will be described on the line of the node $NODE_0$ ~ $NODE_n$ in the column of "Transit probability to other node", and the action or motion to be output at this moment will be described on the line of "Output action". In this connection, the sum of transition probability of each line on the column of "Transition probability to other node" becomes 100[%].

Accordingly, regarding the node $NODE_{100}$ of this example, when the recognition result that "the size (SIZE)" of that ball is from "the range of 0 to 1000 (0, 1000)" is given, it can be transferred to "the node $NODE_{120}$ (node 120)" in the probability of "30[%], and at this moment, the action or motion of "ACTION" will be sent out.

Then, the action model is comprised of a number of nodes $NODE_0$ ~ $NODE_n$ described as the condition transition table 40 linked together.

With this arrangement, when the condition recognition information S10 is supplied from the condition recognition unit 30 and/or the fixed time has been elapsed since the action is conducted the last, the action determining unit 32 determines the next action or motion (action or motion described on the line of "Output action") in utilizing the condition transition table 40 of the corresponding node $NODE_0$ ~ $NODE_n$ from among action model stored in the memory 10A, and outputs the determination result to the emotion/instinct model unit 31 and the action forming unit 33 as the action determination information S12.

(2 - 3) Processing of Action Forming Unit 33

Based on the action determination information S12 to be given from the action determining unit, the action forming unit 33 transmits driving signals $S13_1$ ~ $S13_n$ to the necessary actuators 21_1 ~ 21_n (Fig. 2), and transmits the necessary audio signal S3 to the speaker 20 (Fig. 2), and sends out the LED driving signal S4 to the LED 19.

Thus, based on the driving signals 13_1 ~ 13_n, the action forming unit 33 drives the necessary actuators 21_1 ~ 21_n to the predetermined state, and/or outputs sounds based on the audio signal 3 from the speaker 20, and/or flashes the LED 19 with the flashing pattern based on the LED driving signal S3.

(3) Relationship between Emotion and "Eye" Flashing

Then, in this pet robot 1, the relation between the emotion expression and the flashing of LED 19 tat functions as "eyes" for the sake of appearance will be described in the following paragraphs.

In this pet robot 1, the succeeding action and motion will be determined based on the corresponding condition transition table 40 (Fig. 8) in the action determining unit 32 that is one of functions of the controller 10 as described above.

In this case, the action to flash each green color LED $19G_1$, $19G_2$ out of LED 19 is connected to each output action (such as "ACTION 2" in Fig. 8) corresponded to the recognition result of "patted (PAT)".

Furthermore, at the time when the recognition result of "pat" is given from the condition recognition unit 30, the action determination unit 32 determines the succeeding action and motion in utilizing the corresponding condition transition table 40 as described above, and as well as transmitting the determined action and motion to the action forming unit 33 as the action determining information S12, reads the parameter value of "joy" in the emotion/instinct model unit 31, and informs this to the action forming unit 33.

Thus, at this moment, by driving the necessary actuators 21_1 ~ 21_n, the action forming unit 33 makes it act to express the specified "joy". And also or in place of this, it flashes each

green color LED $19G_1$, $19G_2$ in order that the larger said value becomes the faster the flashing cycle becomes. With this arrangement, the pet robot 1 can express the emotion of "joy" as if it is laughing.

Similarly, the action to flash each red color LED $19R_1$ ~ $19R_2$ in the LED 19 is connected to each output action (such as "ACTION 3" in Fig. 8) corresponded to the recognition result such as "hit (HIT)" in the condition transition table.

Furthermore, when the recognition result "hit" is supplied from the condition recognition unit 30, the action determining unit 32 determines the following action and motion using the corresponding condition transition table 40, and as well as sending the determined action and motion out to the action forming unit 33 as the action determination information S12, reads out the value of parameter of "anger" in the emotion/instinct model unit 31, and informs this to the action forming unit 33.

Thus, at this moment, the action forming unit 33, by driving the necessary actuator 21_1 ~ 21_n based on the action determination information S12 to be given from the action determining unit 32, makes the robot act to express the specified "anger", and also or instead, makes each red color LED $19R_1$, $19R_2$ flash corresponding to the value of parameter of "anger" at that time so that the larger said value becomes the faster the flashing cycle becomes. With this arrangement, the pet robot 1 can express the emotion of "anger" as if it gets angry.

On the other hand, the action to flash each red color LED $19R_1$, $19R_2$ and each green LED $19G_1$, $19G_2$ of LED is connected to each output action (such as "ACTION 4" in Fig. 8) corresponded to the specific recognition result to express the predetermined "surprise" such as "large sound input (SOUND)" in the condition transition table 40.

Furthermore, when the action determining unit 32 is supplied with the specific recognition result to express "surprise" from the condition recognition unit 30, determines the following action and motion in utilizing the corresponding condition transition table 40 and informs the determination result to the action forming unit 33.

Thus, at this moment, the action forming unit 33, by driving the necessary actuator $21_1 \sim 21_n$ based on the action determination information S12 to be given from the action determining unit 32, makes the pet robot 1 conduct the action showing the specified "surprise" and simultaneously, flashes each red color LED $19R_1$, $19R_2$ and each green LED $19G_1$, $19G_2$ successively and alternately. Thus, the pet robot 1 can express the emotion of "surprise" by alternately repeating the expression of laughing and the expression of anger.

With the above arrangement, this pet robot 1 can express the emotion of "joy" to be "patted", the emotion of "anger" to be "hit", and the emotion of "surprise" to the specific recognition result by the flashing each of red LED $19R_1$, $19R_2$ and/or each green

LED $19G_1$, $19G_2$ as expressions.

(4) Operation and Effects of the Present Embodiment

According to the foregoing construction, in this pet robot 1 when the user hits the upper part (touch sensor 17) of the head unit 4, red LED $19R_1$ and $19R_2$ flash simultaneously and said robot expresses the emotion of "anger" as if it gets angry by turning up its eyes. On the other hand, when the user pats said robot, green LED $19R_1$, $19R_2$ simultaneously flash, and the robot expresses the emotion of "joy" as if it is laughing. Moreover, when loud sound is generated in the surrounding area, red LED $19R_1$, $19R_2$ and green LED $19G_1$, $19G_2$ flash alternately and the robot expresses the emotion of "surprise" as if it is surprised by opening and closing its eyes.

Accordingly, in this pet robot 1, the user can easily recognize the emotion condition of this pet robot 1 based on the flashing condition of LED 19. Moreover, since the robot expresses the emotion corresponding to the action of the user such as "pat" and "hit", communications between user and the robot can be more smoothly carried out.

According to the foregoing construction, since the emotion of the pet robot 1 is realized by flashing the LED 19 as "eyes" for the sake of appearance, the communication with the user can be more smoothly conducted, and thereby the pet robot capable of improving the entertainment factor remarkably can be realized.

(5) Other Embodiments

The embodiment described above has dealt with the case of applying the present invention to a four-legged walking pet robot 1 constructed as Fig. 1. However, the present invention is not only limited to this but also can be widely applied to the robotic device having various other shapes (including such as Toy).

Furthermore, the embodiment described above has dealt with the case of applying the LED 19 as the light emitting means. However, the present invention is not only limited to this but also in short, various other light emitting means that emit lights can be widely applied.

In such cases, such as the light emitting element 50 arranged in the array shape and color or black and white display can be applied. And also by applying these light emitting means, a variety of shapes can be displayed as eyes for the sake of appearance, and thereby, a variety of expressions can be expressed.

Furthermore, the embodiment described above has dealt with the case of expressing three (3) emotions (emotional actions), "joy", "anger" and "surprise" according to the light emitting condition of the LED 19 functioning as eyes for the sake of appearance. However, the present invention is not only limited to this but also in addition to these emotions or in place of these emotions, the other emotions (emotional actions) may be expressed according to the light emitting condition of the LED 19.

Moreover, the embodiment described above has dealt with the case of utilizing the LED for 2 colors of red LED $19R_1$, $19R_2$ and

green LED $19G_1$, $19G_2$ as the LED 19. However, the present invention is not only limited to this but also the LED of one color or more than three colors may be prepared and these may be emitted the light with the predetermined light emitting pattern corresponding to emotions.

Furthermore, the embodiment described above has dealt with the case of making the flashing cycle of the LED 19 faster as the stronger the emotion becomes. However, the present invention is not only limited to this but also the brightness of light emitting of the LED 19 may be increased as the stronger the emotion becomes. In short, if the light emitting pattern of the LED 19 would be changed corresponding to the strength of emotion, various other light emitting patterns can be applied as the light emitting pattern.

Furthermore, the embodiment described above has dealt with the case of applying the CCD camera 15, microphone 16 and the touch sensor 17 as the external sensor for detecting the external condition and the external input. However, the present invention is not only limited to this but also, in short, if the sensor that can detect the external condition and the external input, various other sensors can be widely applied as external sensors in addition to and in place of these sensors.

Moreover, the embodiment described above has dealt with the case of applying the memory 10A as the recording medium for recording the control program in the pet robot 1. However, the

present invention is not only limited to this but also, in short, if the recording medium that can record the control program and can reproduce this, various other recording media can be widely applied.

Furthermore, the embodiment described above has dealt with the case of placing the touch sensor 17 on the upper part of the head unit 4 of the pet robot 1. However, the present invention is not only limited to this but also the touch sensor may be placed on the other place. However, by arranging the touch sensor 17 on the forehead or the vertex of the head part, communications between the pet robot 1 and the user can be easily conducted and makes the user easily transfer his feelings toward the pet robot 1. And this is apparent experimentally and from experience.

Furthermore, the embodiment described above has dealt with the case of applying the touch sensor 17 as the means for detecting the motion from the user such as "hit" or "pat". However, the present invention is not only limited to this but also a switch may be placed in place of the touch sensor 17. And detecting the motion such as "hit" from the user by on/off of said switch, the LED 19 may be flashed based on said detection result, and the emotion of pet robot may be expressed.

INDUSTRIAL APPLICABILITY

The present invention can be applied to an entertainment robot such as a pet robot.

CLAIMS

1. A robot comprising:

a light emitting means for functioning as eyes for the sake of appearance;

an external sensor for detecting the external condition and input from outside; and

a control means for flashing said light emitting means in order to express the emotion based on the output of said external sensor.

2. A robot as defined in Claim 1, characterized by:

said light emitting means is formed of light emitting diode.

3. A robot as defined in Claim 1, characterized by:

said control means;

expresses the strength of said emotion by flashing pattern of said light emitting means.

4. A robot as defined in Claim 1, comprising:

a plurality of light emitting means emitting lights of different colors respectively; and characterized by:

said control means;

expresses said emotion by said color of said light emitting means flashing the light.

5. A robot as defined in Claim 1, comprising:

a moving unit; and a driving means for driving said moving unit; and characterized by:

said control means;

expresses said emotion by controlling said driving means and driving said moving unit with the predetermined pattern in addition to the flashing of said light emitting means.

6. A robot as defined in Claim 1, characterized by:

said control means;

updates the emotion model which the pre-held emotion is modeled based on the output of said external sensor; and

determines the emotion based on the emotion model updated; and

flashes said light emitting means so that said emotion determined will be expressed.

7. A robot as defined in Claim 1, characterized by:

said light emitting means;

has the light emitting unit of a plurality of shapes according to said emotion to be expressed.

8. A robot as defined in Claim 1, characterized by:

said robot comprising a head; and

said light emitting means; is placed on said head and covered with a semi-transparent cover.

9. A control method of the robot comprising the light emitting means to function as eyes for the sake of appearance and an external sensor for detecting the external condition and/or inputs from the outside, comprising:

the first step for recognizing said external condition and/or said input from the outside based on the output of said external sensor; and

the second step for flashing said light emitting means to express emotions based on said recognition result.

10. A control method of the robot as defined in Claim 9, characterized by:

said second step;

expresses the strength of said emotion according to the flashing pattern of said light emitting means.

11. A control method of the robot as defined in Claim 9, characterized by:

said robot comprising multiple light emitting means that emit lights with different colors respectively; and

said second step;

expresses the emotion by flashing said colors of said light

emitting means.

12. A control method of the robot as defined in Claim 9, characterized by:

said robot comprising; a moving unit, and a driving means for driving said moving unit; and

said second step;

expresses said emotion by controlling said driving means and driving said moving unit in addition to the flashing of said light emitting means.

13. A control method of the robot as defined in Claim 9, characterized by:

said second step;

updates the emotion model which the pre-held emotion is modeled based on outputs of said external sensor;

determines emotion based on the emotion model updated; and

flashes said light emitting means so that said emotion determined will be expressed.

14. A recording medium in which the control program of the robot having the light emitting means to function as eyes for the sake of appearance and an external sensor for detecting the external condition and/or inputs from the outside is recorded, characterized by:

said control program comprising;

the first step for recognizing the external condition and/or input from the outside based on the output of said external sensor; and

the second step for flashing said light emitting means to express emotions based on said recognition result; and

said control program is recorded onto said recording medium.

15. A recording medium as defined in Claim 14, characterized by:

in said second step;

the strength of said emotion is expressed by the flashing pattern of said light emitting means.

16. A recording medium as defined in Claim 14, characterized by:

said robot comprising multiple light emitting means emitting lights with different colors respectively; and

said second step;

expresses said emotion by said colors flashing of said light emitting means.

17. A recording medium as defined in Claim 14, characterized by:

said robot comprising;

a moving unit, and a driving means for driving said moving unit; and

said second step;

expresses said emotion by driving said moving unit with the predetermined pattern controlling said driving means in addition to flashing said light emitting means.

18. A recording medium as defined in Claim 14, characterized by:

said second step;

updates the emotion model which the pre-held emotion is modeled based on the recognition result at the first step;

determines emotion based on said updated emotion model; and

flashes said light emitting means to express said emotion determined.

ABSTRACT

Since in the robot and its control method and recording medium, the light emitting element to function as eyes for the sake of appearance is flashed so that the emotion can be expressed, the user can easily recognize the emotion of said robotic device based on the light emitting condition of light emitting element. And thus, the attachment and curiosity of the user to the robot can be increased, and the entertainment factor of the robot can be further improved.

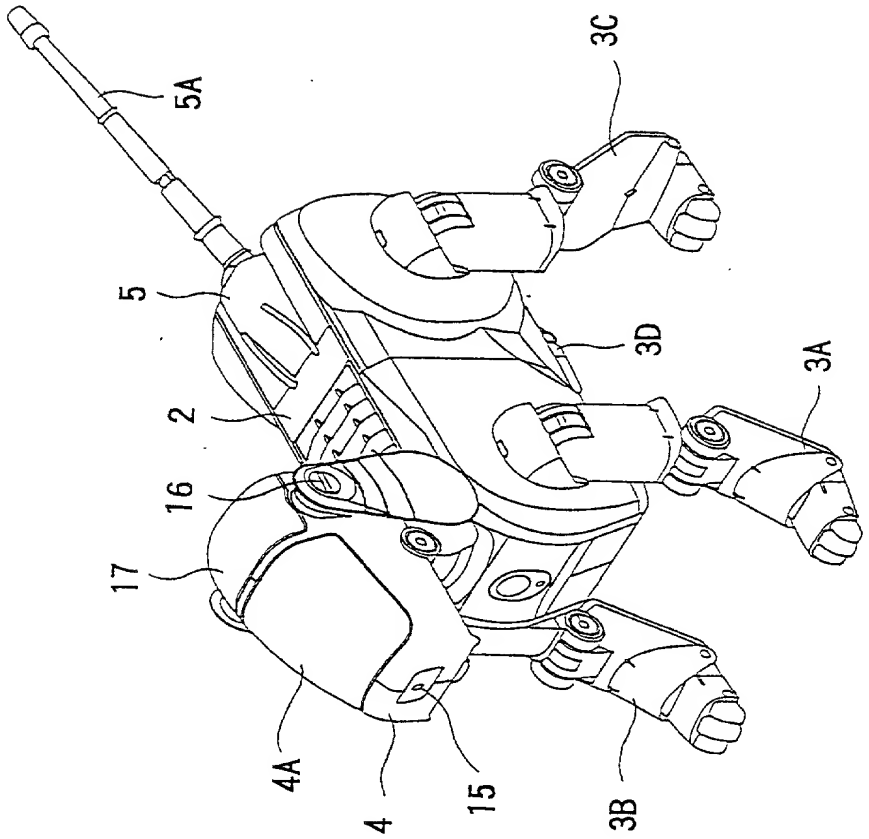


FIG. 1

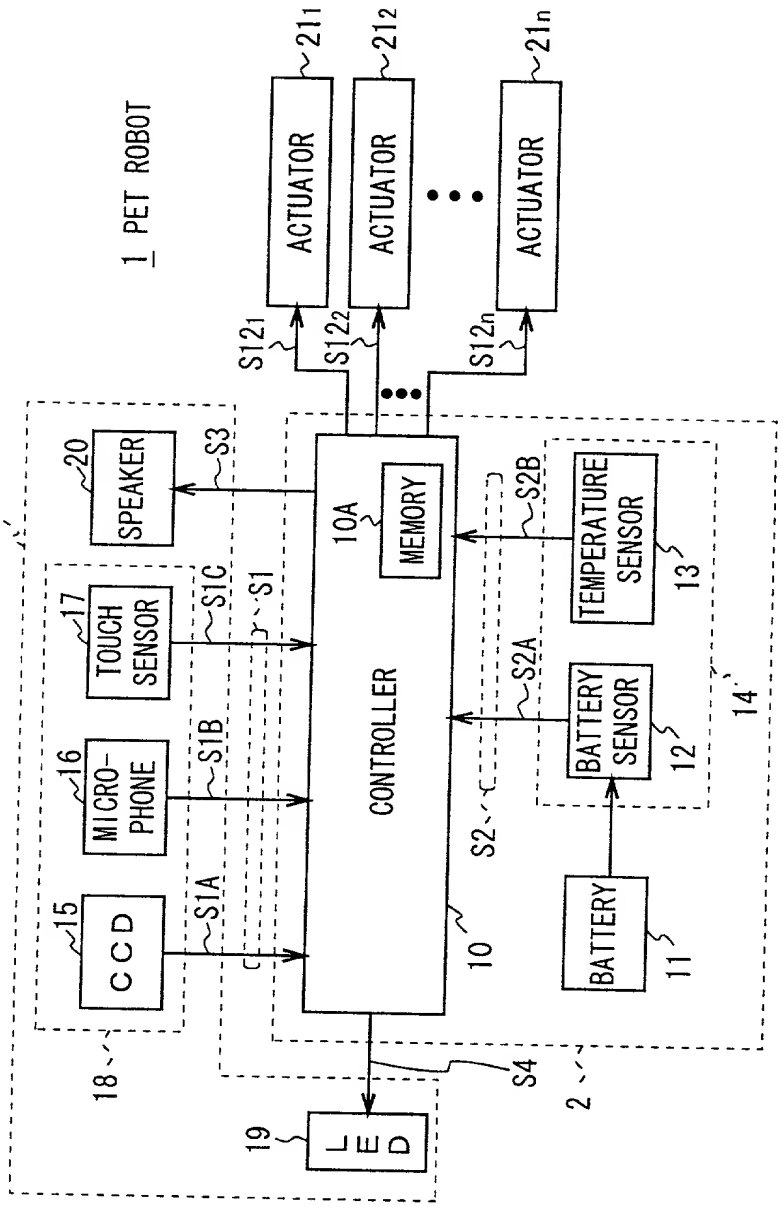

1 PET ROBOT
ACTUATOR
ACTUATOR
ACTUATOR
21_1
21_2
21_n
$S12_1$
$S12_2$
$S12_n$
SPEAKER
20
S3
4
10A
MEMORY
CONTROLLER
10
TOUCH SENSOR
17
S1C
S1
MICRO-PHONE
16
S1B
CCD
15
S1A
18
S2B
TEMPERATURE SENSOR
13
S2A
BATTERY SENSOR
12
S2
14
BATTERY
11
S4
2
19
LED

FIG. 2

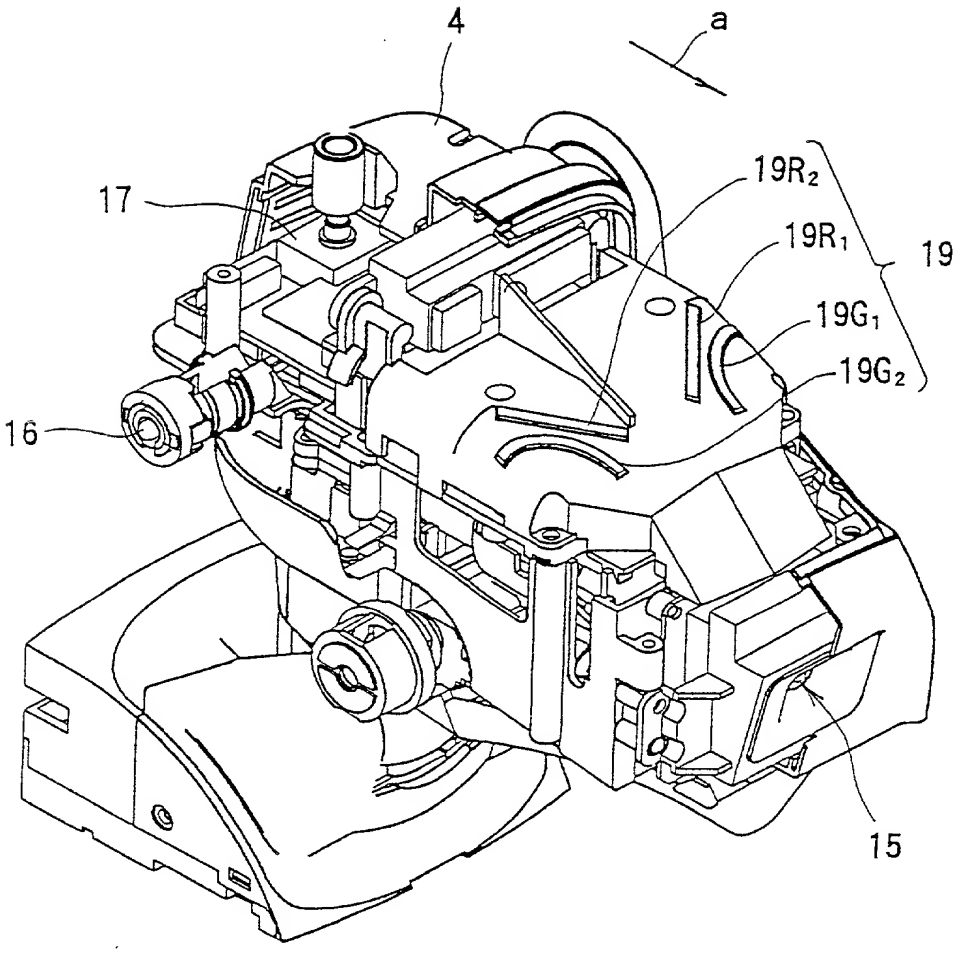


FIG. 3

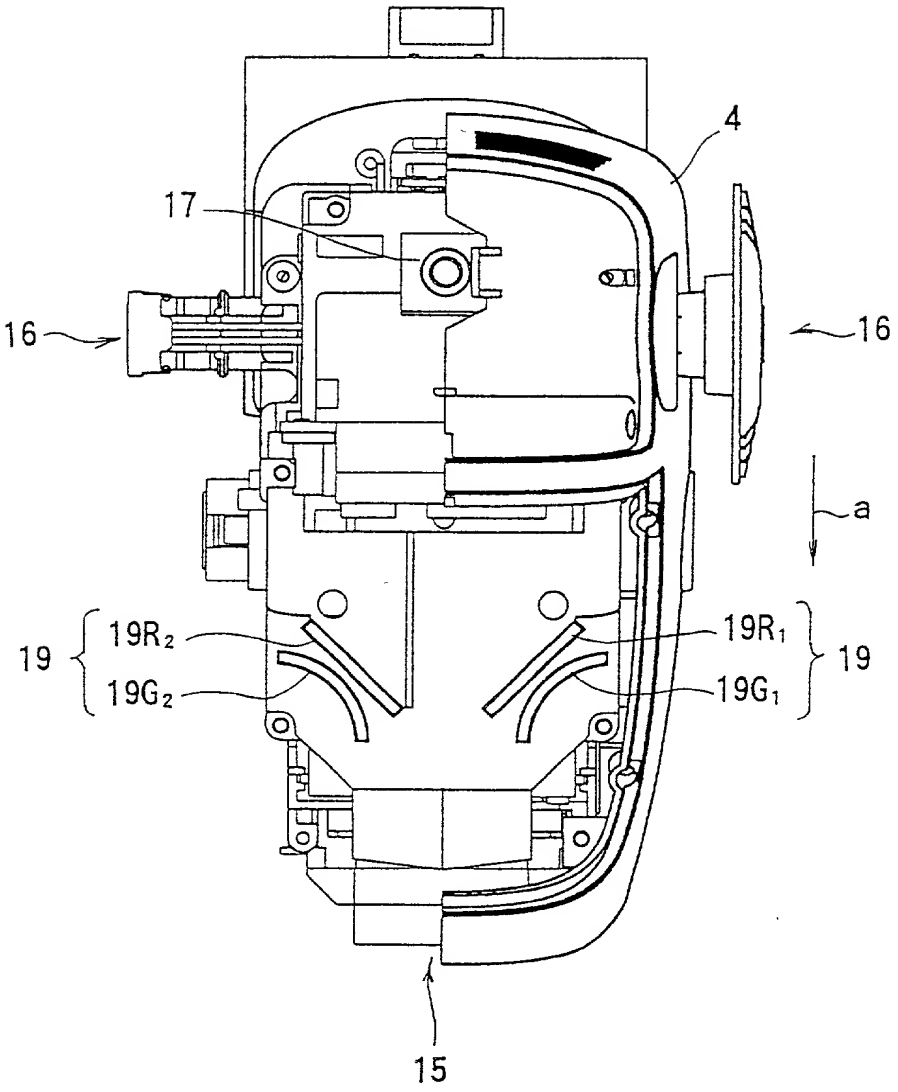


FIG. 4

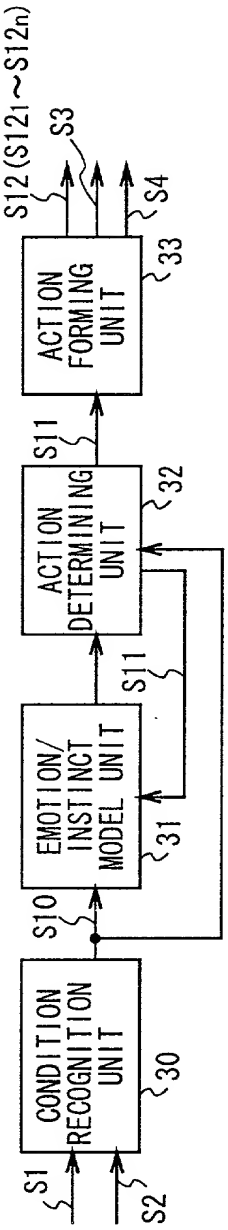

S1
S2
CONDITION RECOGNITION UNIT
30
S10
EMOTION/ INSTINCT MODEL UNIT
31
S11
ACTION DETERMINING UNIT
32
S11
ACTION FORMING UNIT
33
S12 (S12₁~S12n)
S3
S4

FIG. 5

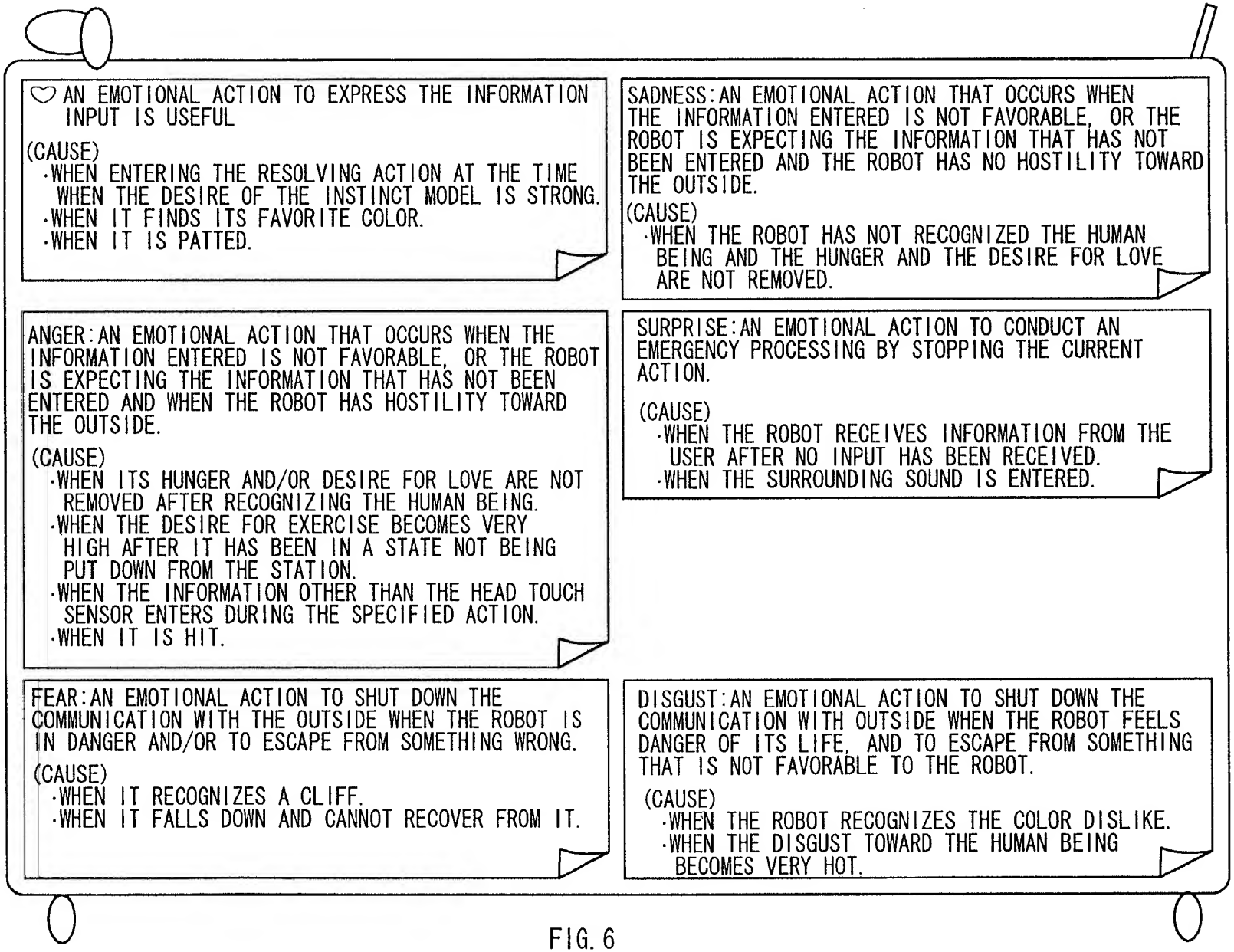


FIG. 6

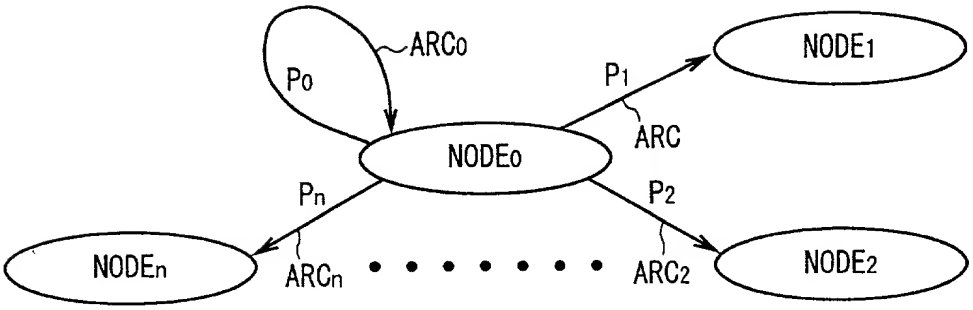


FIG. 7

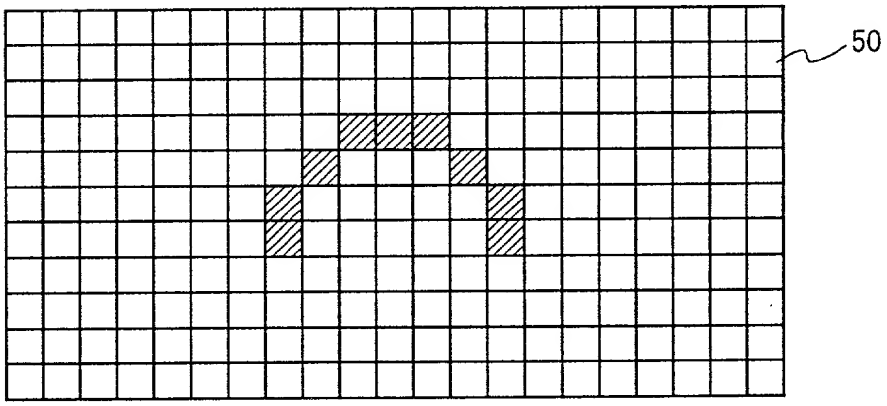


FIG. 9

NODE OF TRANSITTING END / OUTPUT ACTION	NAME OF INPUT EVENT	NAME OF DATA	RANGE OF DATA	TRANSITION PROBABILITY TO OTHER NODE				
node 100				A	B	C	D	n
				node 120	node120	node 1000		node 600
				ACTION 1	ACTION 2	ACTION 3		ACTION 4
1	BALL	SIZE	0, 1000	30%				
2	PAT				40%			
3	HIT					20%		
4	SOUND							50%
5	OBSTACLE	DISTANCE	0, 100					
6		JOY	50, 100					
7		SUPRISE	50, 100					
8		SADNESS	50, 100					

40

FIG. 8

EXPLANATION OF REFERENCE NUMERALS

1 - PET ROBOT, 4 - HEAD UNIT, 4A - SEMI-TRANSPARENT COVER, 10 - CONTROLLER, 10A - TOUCH SENSOR, 15 - CCD CAMERA, 16 - MICROPHONE, 17 - TOUCH SENSOR, $19R_1$, $19R_2$ - RED LED, $19G_1$, $19G_2$ - GREEN LED, $21_1 \sim 21_N$ - ACTUATOR, 30 - CONDITION RECOGNITION UNIT, 31 - EMOTION/INSTINCT MODEL UNIT, 32 - FACTION DETERMINING UNIT, 33 - ACTION FORMING UNIT, 40 - CONDITION TRANSITION TABLE, S3 - AUDIO SIGNAL, S4 - LED DRIVING SIGNAL, S10 - CONDITION RECOGNITION INFORMATION, S11 - ACTION DETERMINING INFORMATION, S12 - DRIVING SIGNAL

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Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

私は、以下に記名された発明者として、ここに下記の通り宣言する：

As a below named inventor, I hereby declare that:

私の住所、郵便の宛先そして国籍は、私の氏名の後に記載された通りである。

My residence, post office address and citizenship are as stated next to my name:

下記の名称の発明について、特許請求範囲に記載され、且つ特許が求められている発明主題に関して、私は、最初、最先且つ唯一の発明者である（唯一の氏名が記載されている場合）か、或いは最初、最先且つ共同発明者である（複数の氏名が記載されている場合）と信じている。

I believe I am the original, first and sole inventor if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

ROBOT AND ITS CONTROL METHOD AND RECORDING MEDIUM

上記発明の明細書はここに添付されているが、下記の欄がチェックされている場合は、この限りでない：

the specification of which is attached hereto unless the following box is checked:

☐ _____ の日に出願され、
この出願の米国出願番号またはＰＣＴ国際出願番号は、
_____ であり、且つ
_____ の日に補正された出願（該当する場合）

☒ was filed on 10 May 2000
as United States Application Number of
PCT International Application Number PCT/JP00/02990
_____ and was amended on
_____ (if applicable).

私は、上記の補正書によって補正された、特許請求範囲を含む上記明細書を検討し、且つ内容を理解していることをここに表明する。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編規則１．５６に定義されている、特許性について重要な情報を開示する義務があることを認める。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

日本語宣言書

私は、ここに、以下に記載した外国での特許出願または発明者証の出願、或いは米国以外の少なくとも一国を指定している米国法典第３５編第３６５条(a)によるＰＣＴ国際出願について、同第１１９条(a)-(d)項又は第３６５条(b)項に基づいて優先権を主張するとともに、優先権を主張する本出願の出願日よりも前の出願日を有する外国での特許出願または発明者証の出願、或いはＰＣＴ国際出願については、いかなる出願も、下記の枠内をチェックすることにより示した。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT international application having a filing date before that of the application for which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

Priority Not Claimed
優先権主張なし

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed)	
11-129279	Japan	10 May 1999	☐
PCT/JP00/02990	PCT	10 May 2000	☐
			☐
			☐
			☐
			☐

私は、ここに、下記のいかなる米国仮特許出願についても、その米国法典第３５編１１９条(e)項の利益を主張する。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)

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I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365© of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可、係属中、放棄)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

日本語宣言書

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact al business in the Patent and Trademark Office connected therewith (list name and registration number)

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DENNIS M. SMID, Registration No. 34,930

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full name of second joint inventor, if any

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第二共同発明者の署名　　日付

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（第三以下の共同発明者についても同様に記載し、著名をすること）

(Supply similar information and signature for third and subsequent joint inventors)